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SUBJECT—

TITLE

THE USE OF AERIAL PHOTOGRAPHY FOR FOREST INSECT SURVEYS

by
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Portland, Oregon

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LABORATORY

Forest Insect Laboratory,
445 U. S. Court House,
Portland, Oregon

Laboratories
Berkeley, Coeur d'Alene, Fort Collins and Ogden December 4, 1950

J. M. Whiteside, Acting in Charge, Portland Laboratory

"The Use of Aerial Photographs for Forest Insect Surveys", a talk to be given by J. F. Wear at the American Society of Photogrammetry Meeting, San Francisco, California, December 5, 1950.

J. F. Wear and J. W. Bongberg are scheduled to talk on the subject "Control of Forest Insects" as a panel discussion covering the "Use of Aerial Photos in Forest Protection" at the above-mentioned meeting. Mr. Wear has prepared the following paper for his portion of the discussion.

At first, no formal paper was considered; however, in order to stay within his fifteen-minute time limit, Mr. Wear prepared a paper. Since this paper will not be published, it is being submitted for your information. Any comments you care to make will be appreciated.

Enclosure

cc: Dr. Beal

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THE USE OF AERIAL PHOTOGRAPHY FOR FOREST INSECT SURVEYS

By

J. F. Wear

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United States Department of Agriculture

Agricultural Research Administration

Bureau of Entomology and Plant Quarantine

Division of Forest Insect Investigations

Portland, Oregon

(For presentation at the Forest Photogrammetry meeting sponsored by the Northern California Section of the American Society of Photogrammetry, San Francisco, California, December 5, 1950.)

Surveys of many types have been conducted over most of the timbered areas of the West during past years. These surveys have not been limited to the detection of forest insect damage but have also been used to appraise the losses arising from fire, disease, windstorm, or erosion. Through information obtained from detection and appraisal surveys the western forest insect laboratories of the Bureau of Entomology and Plant Quarantine have endeavored to keep state, private, and federal land-managing agencies fully aware of the current activities and potential dangers of the many significant forest insects, and, through research activities have provided the methods by which epidemic outbreaks can be economically controlled. Forest insect surveys and control of forest insect infestations are two interrelated programs that have been developed through the application of knowledge

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gained through research. As new facts and concepts of the forest insect picture develop through research so will the survey and control programs continue to change and improve.

Ground methods for making forest insect surveys have not always provided the most satisfactory regional insect survey information. Adequate ground coverage of large and often inaccessible areas on an annual basis is not possible with the limited time, manpower, and funds available each season. In recent years cooperative aerial surveys have been used successfully to supplement, and in some cases to replace, ground surveys in covering large areas of forest land both rapidly and economically. An example of the value of an annual region-wide aerial survey for the detection of forest insect outbreaks is the cooperative surveys conducted by the Oregon State Board of Forestry and the Portland Forest Insect Laboratory to locate epidemic infestations of the spruce budworm prior to the planning of large-scale control operations in Oregon and Washington.

The most widely used aerial survey method for forest insect detection on the West Coast today is of the general reconnaissance type. This method involves the sketchmapping, usually on ¼ inch to the mile scale maps, of forested areas visible from the air that have been attacked by either defoliator or bark mining insects. In this manner the 49,000,000 acres of forested land in Washington and Oregon are now being surveyed annually. By locating centers of insect outbreaks and delineating them from the air, the general distribution and damage intensity can be appraised on a region-wide basis. The

reconnaissance survey does not attempt to estimate the actual volume loss per acre or per section but depends upon ground surveys for this information. Once the aerial reconnaissance survey has been made, ground crews can then be directed to localized areas to make accurate estimates through intensive examination and with a minimum expenditure of time and money. Data obtained from ground and aerial surveys provide the necessary information for planning control programs on critical areas.

The western forest insect laboratories recognize the fact that a detection survey method used in one region does not necessarily apply in another. Intensity of coverage needed in each region varies with the habits and destructiveness of the various species of forest insects, the timber type, and the values involved. In order to provide adequate coverage of the important forest areas of the west, present survey methods must be expanded and extended. New survey methods and techniques must be developed to handle the variety of conditions encountered in different parts of the various regions. The most recent experimental research in the aerial survey phase of forest insect detection is in the use and application of aerial photography to the bark beetle problems in ponderosa pine and Douglas-fir stands.

The first aerial photographic experiment, to determine the feasibility of using aerial photos as a survey tool in detecting and appraising outbreaks of the western pine beetle, was made by J. M. Miller of the Berkeley Laboratory in 1925 in cooperation with the Army Air Service's 15th Photo Section. Further tests were conducted by F. P. Keen in 1927. Notwithstanding the slow emulsion speed of the film and glass plates of that time, the results of these early

experiments were most promising. It was found that infested bark beetle trees could be differentiated on the photographs. Little progress in aerial photography for forest insect detection was made after these initial experiments until 1947 when a biplane was acquired by the Portland Forest Insect Laboratory for conducting experiments in aerial photography and phases of aerial detection and appraisal surveys.

The first photographic experiments were undertaken in the fall of 1947 in the open ponderosa pine stands of eastern Oregon where ground checking was easier than in the dense west-side forests. One of the first objectives was to determine how well barkbeetle-killed trees registered on the fast emulsion speed film developed during World War II. Stereo interpretation of the test photos revealed the bright sorrel-colored foliage of trees killed by the 1947 spring brood of the beetle to appear in sharp contrast to the living trees. However, many insect-killed trees in intermediate stages of coloring, between straw yellow and dull sorrel, did not show marked differences from living trees. Differences in crown structure and needle complement of individual trees also complicated the interpretation. It was soon apparent that experiments involving investigation of basic factors of aerial photography, scale, film and filter, would be necessary in order to improve the accuracy of stereo interpretation. The amount of ground detail and tree form information required for accurate interpretation eliminated the scales above 1/10,000. Scales of 1/7500, 1/5000, and 1/2500 were selected as being the most likely to solve the scale problem. Super X Panchromatic film was used with several filters in the first test.

Results as to which scale was best were not conclusive, but from the standpoint of ease of stereo interpretation with 60 per cent overlap, plot area covered per photograph, and cost per acre on a survey basis, the 1/5000 scale photography showed the best possibilities. However, all three scales have been used in subsequent tests to statistically prove the validity of this assumption.

As mentioned above, several filters were used at the different scales. In addition to haze-cutting qualities, different filters will either increase or decrease contrast between certain colors. Photo test conditions (haze, season of the year, time during the day when photographs are taken) have varied with each replication and thus have introduced additional variables. Since stereo interpretation of all filter combinations has not been possible, due to the pressure of spruce budworm control projects and region-wide aerial reconnaissance surveys, statistical data have not been calculated to evaluate the filters used. However, examination of the first series of photographs indicated the A-25 filter to be the most effective in distinguishing bark beetle loss.

Aerial photo experiments in 1948 attempted to extend the possibilities of bark beetle appraisal by including infrared and kodacolor films. A comparison of panchromatic and infrared films indicated the panchromatic to be better than the infrared from the interpretation standpoint. Many bug trees on infrared appeared dark grey and could hardly be separated from the shadows. The foliage of other beetle-killed trees reflected as much infrared rays as did living trees and made them appear as such. Detection of bug trees on infrared film was

consequently poor. Color photography on the other hand presented good color contrast between sorrel foliage and green foliage, but the slow emulsion speed of kodacolor film and the bright ground reflections from certain light-colored soils did not favor sharp definition of tree form and ground detail. Straw-colored foliage of fresh-killed trees was not always discernable from live green foliage. Only through further tests, however, can the superiority of color over panchromatic or infrared film be determined.

When the Bureau of Entomology and Plant Quarantine purchased a more efficient airplane (a Cessna 195) for western aerial surveys and aerial survey research late in 1949, the Berkeley and Portland laboratories formulated extensive aerial survey technique experiments to be conducted in the spring of 1950. The cooperative project, to be conducted in the pine type characteristic of northeastern California and eastern Oregon and Washington, considered three main fields of investigation: (1) To evaluate aerial reconnaissance methods, (2) To evaluate aerial strip-counting methods, and (3) To evaluate aerial photographic methods. The immediate objectives of the study were to determine the effectiveness of existing aerial methods for pine beetle surveys, to improve old methods and devise new techniques and equipment, to apply these methods and techniques to areas of different loss intensities, to determine to what extent aerial methods can replace or supplement ground methods, and to determine the comparative costs of aerial and ground surveys.

Since the aerial reconnaissance method has been discussed previously, the basic procedure and the more promising results of the aerial strip

counting method will now be considered. An aerial strip viewer designed by W. J. Buckhorn of the Portland laboratory, mounted in the floor of the Cessna 195, provides a five-chain strip of observation area when the plane is flown at a prescribed altitude above the ground. Accurate flight altitude above the ground was maintained in the series of tests by using a radio altimeter. At 800 feet an experienced observer, looking through the strip viewer, can count the number of trees having discolored foliage and estimate the year of kill with considerable accuracy. Random strips can be flown over known distances and the visual loss recorded. Through experience and ground checking of aerial observations the observer will determine a factor which will compensate for the trees missed or incorrectly dated. Application of this factor to the recorded loss will immediately provide a loss figure for the area. Further tests will be conducted to statistically evaluate the accuracy of aerial strip counts for bark beetle surveys.

The final experimental phase of the Berkeley-Portland project was to make an intensive study of aerial photographic methods for appraising ponderosa pine loss due to bark beetles. In previous aerial photographic tests there had been no comprehensive statistical evaluation of what scale, film and filter combination give the best results. The 1950 photo tests provided the information necessary to statistically analyze the aerial photographic method for bark beetle detection in ponderosa pine.

A 160-acre test plot, located 16 miles northwest of Fall River Mills, California, was selected for the aerial photographic tests

due to the relatively large number of bark beetle trees present and due to the wide range in color conditions of the foliage. The corners of the plot were marked with white crosses which were visible from the air and on the printed photographs.

Panchromatic, infrared, and color films were exposed under optimum conditions on May 29 and 30 at three scales; 1/2500, 1/5000, and 1/7500. Six filter combinations were interchanged in exposing the panchromatic film, and four with the infrared. The color film required only an emulsion filter plus a haze correction filter for proper exposure based on light meter readings. A special attachment was designed for the K-17, 12-inch focal length camera to expedite the changing of filters in the air.

After all films were processed in the Portland Laboratory darkroom, the panchromatic and infrared black and white prints and the color transparencies were edited by members of the Berkeley staff. It was found that full stereoscopic coverage of the 160 acre plot was not obtained in every film-filter combination. For this reason a smaller plot, approximately 11 acres in size and containing a heavy concentration of dead and dying trees was delineated within the 160 acre plot. On this small plot, a key was obtained from a ground cruise of tree mortality, giving for each tree the amount of dead crown, year of kill, and height, for use in determining the accuracy of photo interpretation.

Before turning the discussion of interpretation procedures and the application of aerial photographic methods to aerial surveys in

the ponderosa pine region over to Jack Bongberg, I should like to briefly discuss a cooperative mortality study conducted in western Oregon Douglas-fir stands in June of this year.

Public agencies and timber owners have long recognized the need for more reliable estimates of tree mortality in the Douglas-fir region. Present methods of using small plots for inventory and mortality data are often inadequate, and detailed cruises of large areas are too expensive. The cooperative mortality study conducted in Coos and Josephine Counties in southwest Oregon was undertaken by representatives of the Pacific Northwest Forest and Range Experiment Station, the Division of Forest Pathology of the Bureau of Plant Industry, the Bureau of Land Management, the Oregon State Board of Forestry, and the Portland Forest Insect Laboratory. The objectives were to develop aerial techniques that would; (1) provide mortality estimates for the inventory phase of the forest survey and the annual forest insect survey, and (2) improve existing techniques for detecting insect and disease outbreaks during the course of aerial detection surveys in the dense west-side forests.

The number, size, and kind of samples to be taken were determined by such factors as time, manpower, available funds and the adaptability of the sample to statistical analysis. Thirty plots, 1 chain wide by 1 mile long, were selected at random using the Region 6 forest survey system. Plot locations were transferred to ¼ inch to the mile base maps and 1/20,000 scale aerial photographs to enable the photo and ground crews to locate the plots.

It had been hoped that results of the Berkeley-Portland aerial photographic tests would provide the answer as to the best scale and filter for mortality detection when using panchromatic film. Cursory examination of the 1/5000 scale photographs of the ponderosa pine area indicated the K_1 filter to be satisfactory. In order to obtain uniform scale for all photo plots the plane's radio altimeter was relied upon to give a minimum scale of 1/4000 over any plot. Several dry runs were necessary to establish the elevation of the tops of ridges on each plot of the rough terrain that is typical of southwestern Oregon. Super XX Pan with K_1 filter and Ektachrome color film were exposed on the thirty plots.

One set of the resulting panchromatic photographs was taken into the field by each of the two three-man crews doing the ground work. In the field, the crews plotted on the photographs in place, (1) the center line of the plot, (2) the trees killed within the past five years, and (3) the distance along the center line in 2-chain intervals. Additional data recorded on forms consisted of (1) green stand cruise volume, (2) site data, and (3) description of the killed trees as to length of time dead, cause of death and stand position.

Interpretation of the photographs got underway after all field work had been completed. Two interpreters from the forest survey staff and two interpreters from the Portland Forest Insect Laboratory have almost completed the stereoscopic examination of 15 plots each. Pocket stereoscopes have been used on both the panchromatic prints and the colored transparencies.

The results of this mortality study have not been fully evaluated as yet but several aspects of the interpretation are evident. (1) The east side stands are more easily interpreted than are the dense west side stands, (2) Penetration of shadows for ground detail in dense stands is very difficult with only a very small proportion of downed trees visible, and (3) Color photography does not show marked advantages over panchromatic for accuracy in distinguishing tree mortality in Douglas fir stands. First impressions of the interpretation are not too encouraging, but the value of these thirty new permanent photo plots lies in the future when one-year or five-year reinspection by aerial photography will disclose the mortality due to insects, disease, and windstorm.